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ENERGY AND SUSTAINABLE DEVELOPMENT: ISSUES CONCERNING OVERALL ENERGY DEVELOPMENT, WITH PARTICULAR EMPHASIS ON DEVELOPING COUNTRIES

Changing global energy patterns

Report of the Secretary-General

SUMMARY

By resolution 46/235, the General Assembly decided to establish the Committee on New and Renewable Sources of Energy and on Energy for Development. The Committee will retain the mandate of the Committee on the Development and Utilization of New and Renewable Sources of Energy, including the consideration of its relation to environment and development. It will also take over the mandate of the Committee on Natural Resources pertaining to energy, as defined in Economic and Social Council resolution 1535 (XLIX) of 27 July 1970. In addition, the Committee will address relevant issues contained in Agenda 21 pertaining to energy and related programmes and activities.

The present report analyses changes in global energy consumption and production patterns, particularly with regard to fossil fuels to the year 2020, and evaluates the adequacy of reserves and resources in the light of rapidly developing technologies. Issues on new and renewable sources of energy and Agenda 21 are covered in the report of the Secretary-General on an update on new and renewable sources of energy (E/C.13/1994/3).

* E/C.13/1994/1.

Energy consumption is expected to increase at higher rates in the developing world as compared to the developed market economies. By the year 2020, the share of the developing countries in the consumption of world fossil fuels may reach 48 per cent, from the current level of 26 per cent. High energy intensities are expected to continue in the developing countries in view of the higher growth rates in economic output. Yet, their per capita gross domestic product and energy consumption will remain much lower than in all other countries.

Because of the wide application of rapidly changing technologies in the exploration and development of energy resources, higher energy consumption is accompanied by increasing global reserves which are more than adequate to the mid-twenty-first century. Yet a rapid growth in energy consumption, especially of fossil fuel, gives rise to environmental concerns.

New energy financing mechanisms are analysed in the context of recent political transformations and widespread adoption of free market policies.

The report concludes by pointing out that energy shortages in several developing countries, as well as in the economies in transition, often cause severe losses of economic output. The number of the energy poor is growing. While national efforts to alleviate these problems are essential, their solution would require expanded international cooperation and special measures.

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INTRODUCTION

1. The world energy situation at present may be characterized as one of relative tranquillity because of abundant reserves of fossil fuels, stable prices, continuing progress in energy conservation and efficiency, significant advances in energy technologies and a widespread adoption of free market policies.

2. However, this tranquillity is accompanied by a variety of concerns, including security of supply and demand, especially for oil and increasingly for natural gas, and environmental problems caused by the production, transportation and use of fossil fuels.

3. Tentative steps to promote international cooperation in energy have been initiated, for example, in conferences between oil producers and consumers and negotiations for a European energy charter and the United Nations Framework Convention on Climate Change and in the adoption of Agenda 21 by the United Nations Conference on Environment and Development.

4. Still, much of the developing world continues to depend on traditional energy sources. With increasing population, energy scarcities are widespread. Lack of capital and technological capacities hinder the development of adequate commercial energy supplies, with consequent deleterious effects on economic and social development. On the eve of the twenty-first century about 2.5 billion people in the developing countries have no access to commercial energy supplies and electricity.

5. The promises of new sources of energy such as solar and wind have remained just that. Lack of technological breakthroughs and other obstacles have limited progress to isolated cases with minimal impact on national economies.

6. Despite considerable efforts by the international community in technical and financial assistance, serious energy problems in a majority of the developing countries remain unresolved. Yet, a considerable number of developing countries have developed capacities to manage much of their energy affairs, as evidenced by a multitude of energy enterprises, including national oil and gas companies and electricity authorities.

7. Energy prospects, especially in the developing world, give rise to a variety of concerns. Because of lower oil prices since the early 1980s and especially since 1986, the value of energy exports of developing countries has been deteriorating. For example, the value of oil exports of the member countries of the Organization of the Petroleum Exporting Countries (OPEC) was reduced from $284 billion in 1980 to $135 billion in 1992. 1/ Such developments have given rise to hesitations in committing considerable financial resources for additional production capacities which will be required to meet increasing demand from the industrialized countries and other developing countries. At the same time, higher taxes in consuming countries, particularly on oil products, often imposed for both budgetary and environmental objectives, may cause economic, social and political problems as well as mistrust and tensions in several energy-exporting developing countries.

8. In energy-importing developing countries, access to and development of commercial energy supplies for economic growth are urgent priorities. However, it is generally felt that solutions to urgent and severe local environmental problems in those countries, as well as more efficient energy production and use, can be achieved only through economic growth which has to be based on higher commercial energy supplies.

9. With the population explosion expected to add 2.67 billion, for a total of 6.7 billion in the developing world by the year 2020, increases in energy demand in those countries are inevitable. Available forecasts of economic growth in the developing world as a whole indicate higher rates than in other socio-economic groups of countries. Consequently, developing countries are expected to absorb a greater proportion of incremental energy demand. By the year 2020, demand for fossil fuels in those countries may reach 6,563 million tons of oil equivalent (mtoe), or 47.7 per cent of the world total, from the current 1,782 mtoe and only 25.9 per cent of world consumption. However, their per capita consumption of fossil fuels will then still be about 1,003 kilograms of oil equivalent (koe), as compared to 4,525 koe in the industrialized countries.

10. Such expectations on energy developments in the developing world have already given rise to concern about possible pressures on supplies of conventional oil and gas and impacts on climate change through the emission of carbon dioxide, especially from coal.

11. For the developing countries, the primary concern is to achieve steady and sizeable rates of economic growth for a better standard of living for their growing population. Energy poverty has to be overcome in order to achieve this objective. Massive investments will be required for the exploration and development of indigenous energy resources and their efficient utilization in an environmentally sustainable manner.

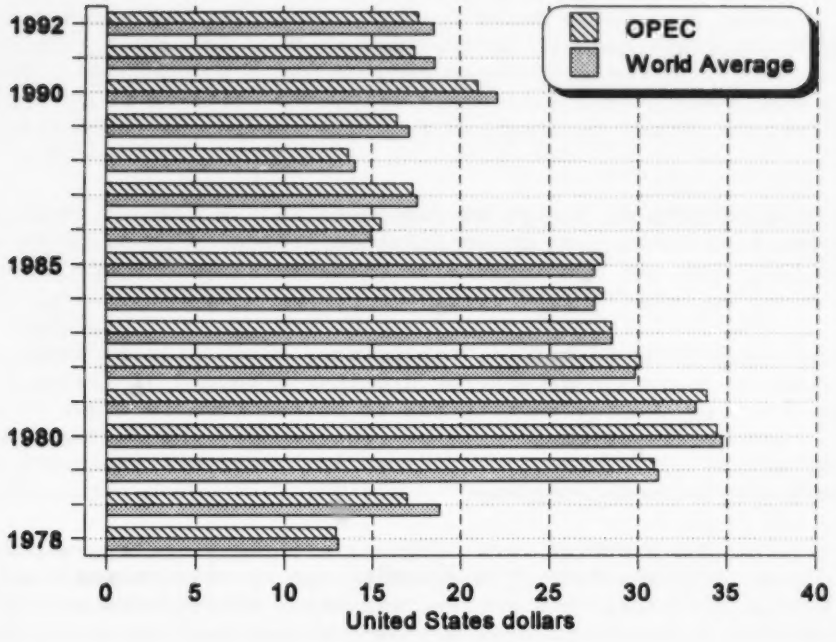
12. While it may be expected that national efforts of energy-exporting developing countries may be supplemented by appropriate cooperation measures, especially from major energy importers and their enterprises in the developed market economies, special measures by the international community in the provision of capital and technologies will be required in the energy-deficient developing world. This challenge has long been recognized by the United Nations General Assembly in repeated resolutions on the development of the energy resources of the developing countries. However, no follow-up programmes have as yet been formulated. 2/

I. CHANGING ENERGY CONSUMPTION PATTERNS

13. During the past four decades, economic development throughout the world has been feasible because of the ready availability of increasing commercial energy supplies. The reconstruction of war-torn economies was fuelled mostly by coal and later on by natural gas from national sources, as well as by a rapidly expanding influx of oil from the developing world, mainly the Middle East, at ever-declining prices until the beginning of the 1970s.

14. The energy crises of 1973/74 and 1979/80 brought about massive and abrupt increases in energy prices, which caused transfers of wealth from consumers to producers and serious balance-of-payments problems, especially for many energy-importing developing countries, until the oil price collapse of 1986. Since then, oil prices have settled within a range of approximately $15-20 per barrel, except for the period of the Persian Gulf crisis during 1990/91 (see figure).

Crude oil prices, f.o.b.



Source: UN/DPCSD, based on United States Department of Energy, Energy Information Administration, Weekly Petroleum Status Report, various issues.

15. Primary energy sources are mostly used after processing and transformation into secondary products such as gasoline and electricity. In most cases, the above-mentioned fluctuations in energy prices had only a limited impact on consumption because they were not fully passed on to the consumers. In many countries, particularly in the industrialized world, excise taxes on energy, particularly oil products, have been consistently rising to the point where the price of an energy product is now many times the sum of its cost of production, transportation, refining and distribution.

16. Higher energy consumer prices during the past two decades, as well as a variety of policies and measures aimed at energy conservation and efficiency and new structures of national economies, including the energy industries, have led to changes in energy consumption patterns, as shown in tables 1 and 2.

17. Despite many changes over the years in the composition of energy consumption at the global and national levels, fossil fuels continue to be of overwhelming importance. By 1991, fossil fuels were contributing 95 per cent of world energy consumption despite a more than threefold increase in electricity from hydro, nuclear and geothermal sources between 1970 and 1991. Similarly, out of an increase of 3,113 mtoe in world energy consumption during the same period, over 90 per cent was due to increases in the consumption of fossil fuels.

18. Most of the increase in world energy consumption, about 58 per cent, during the period 1970-1991 was in the developing countries, as compared to 18 per cent in Eastern Europe and the former Soviet Union and 24 per cent in the developed market economies.

19. Within the various groups of countries, in addition to changes in overall energy consumption patterns, significant changes also occurred with regard to the type of energy consumed.

20. In the developed market economies there was a pronounced shift away from oil, as shown in tables 1 and 2. In fact, oil consumption in those countries dropped between 1980 and 1985, and even though increases have been registered since then, the level of oil consumption was still lower in 1990 as compared to 1980. This shift was brought about through higher taxes, especially on oil products, technological improvements in oil efficiencies, structural changes in national economies, massive investments in alternative energy supplies, especially coal and nuclear power, and deliberate policies, including administrative restriction in the use of oil, for example in electricity generation. Still, oil continues to contribute about 42 per cent of energy consumption in those countries, as compared to 49.6 in 1980.

21. In Eastern Europe and the former Soviet Union, changes in energy consumption patterns were based on a massive expansion of natural gas and relatively little change, especially after 1980, in oil, coal and electric power.

Table 1. Commercial primary energy consumption

(Million tons of oil equivalent)

		1970	1980	1991	Growth rate, 1990-1991 (percentage)
Developed market economies	Oil	1 432.0	1 665.3	1 536.0	0.33
	Gas	659.6	765.2	885.1	1.40
	Coal	718.4	784.2	969.8	1.43
	Electricity	77.9	142.1	243.6	5.44
	Total	2 887.9	3 356.8	3 634.5	1.10
Central Europe and CIS	Oil	271.1	465.7	513.9	3.05
	Gas	192.2	385.6	631.4	5.68
	Coal	518.1	589.2	371.0	-1.59
	Electricity	12.1	25.0	46.0	6.38
	Total	993.5	1 465.5	1 562.3	2.16
All developing countries	Oil	267.1	554.5	991.1	6.26
	Gas	49.6	131.9	286.3	8.38
	Coal	270.5	463.2	1 048.9	6.47
	Electricity	16.8	42.4	75.5	7.18
	Total	604.0	1 192.0	2 401.8	6.59
Member countries of OPEC	Oil	37.6	110.6	293.2	9.82
	Gas	24.2	57.6	145.4	8.57
	Coal	1.0	1.6	7.1	9.37
	Electricity	0.8	2.4	4.9	8.66
	Total	63.6	172.2	450.6	9.36
Oil-exporting developing countries	Oil	70.0	163.6	292.7	6.83
	Gas	16.8	50.0	71.5	6.92
	Coal	179.8	310.3	758.3	6.87
	Electricity	4.9	10.3	24.8	7.75
	Total	271.5	534.2	1 147.3	6.88
Oil-importing developing countries	Oil	159.5	280.3	405.3	4.45
	Gas	8.6	24.3	69.4	9.98
	Coal	89.7	151.3	283.5	5.49
	Electricity	11.1	29.7	76.2	9.21
	Total	268.9	485.6	834.4	5.40
TOTAL WORLD	Oil	1 970.2	2 685.5	3 041.0	2.07
	Gas	901.4	1 282.7	1 802.8	3.31
	Coal	1 507.0	1 836.6	2 389.7	2.20
	Electricity	106.8	209.5	365.1	5.87
	Total	4 485.4	6 014.3	7 598.6	2.51

Source: UN/DPCSD, based on Energy Statistics Yearbook, various issues.

Table 2. Commercial primary energy consumption patterns

(Percentage)

		1970	1980	1991
Developed market economies	Oil	49.6	43.9	42.3
	Gas	22.8	22.3	24.4
	Coal	24.9	21.5	26.7
	Electricity	2.7	6.6	6.7
	Total	100.0	100.0	100.0
Central Europe and CIS	Oil	27.3	26.4	32.9
	Gas	19.3	38.4	40.4
	Coal	52.1	32.4	23.7
	Electricity	1.2	2.8	2.9
	Total	100.0	100.0	100.0
All developing countries	Oil	44.2	39.6	41.3
	Gas	8.2	14.1	11.9
	Coal	44.8	42.3	43.7
	Electricity	2.8	4.0	3.1
	Total	100.0	100.0	100.0
Member countries of OPEC	Oil	59.1	54.2	65.1
	Gas	38.1	42.6	32.3
	Coal	1.6	1.5	1.6
	Electricity	1.3	1.7	1.1
	Total	100.0	100.0	100.0
Oil-exporting developing countries	Oil	25.8	27.4	25.5
	Gas	6.2	8.0	6.2
	Coal	66.2	62.5	66.1
	Electricity	1.8	2.2	2.2
	Total	100.0	100.0	100.0
Oil-importing developing countries	Oil	59.3	48.4	48.6
	Gas	3.2	8.8	8.3
	Coal	33.4	35.5	34.0
	Electricity	4.1	7.3	9.1
	Total	100.0	100.0	100.0
TOTAL WORLD	Oil	43.9	38.7	40.0
	Gas	20.1	23.9	23.7
	Coal	33.6	32.4	31.4
	Electricity	2.4	5.0	4.8
	Total	100.0	100.0	100.0

Source: UN/DPCSD, based on Energy Statistics Yearbook, various issues.

22. In the developing world as a whole, considerable changes occurred in all types of energy, including primary electricity based on hydropower rather than on nuclear expansion. Apart from a few coal producing and consuming countries such as China and India, oil consumption dominated the commercial energy scene in most of the developing world.

23. Overall energy demand during the period 1970-1991 increased by 2.5 per cent per annum; annual rates of growth varied from 1.1 per cent in the developed market economies to 2.2 per cent in Eastern Europe and the former Soviet Union and 6.6 per cent in the developing world (see table 1). Among the developing countries, the member countries of OPEC and other oil-exporting developing countries registered annual growth rates of 9.4 and 6.9 per cent respectively and the oil-importing developing countries, 5.4 per cent. However, analysis of energy consumption changes in 136 developing countries and territories between 1980 and 1991 reveals that 21 of them had a drop in total energy consumption and 45 of them a drop in per capita energy consumption during the same period because of acute economic problems and/or civil wars and political instability.

24. The above-mentioned higher rates of growth in energy demand in the developing countries as compared to the industrialized countries are generally expected to continue in the foreseeable future. This expectation is based on projections that show a population explosion and relatively high economic growth rates, accompanied by improved but nevertheless high energy intensities because of the stage and structure of their economies and the relative scarcity of capital, technology and expertise, which will hinder the widespread application of energy-saving measures and techniques.

25. If past trends continue into the foreseeable future, energy demand may be expected to grow at an annual rate of 1-2 per cent in the developed market economies and 5-7 per cent in the developing countries. For the developing world, such a scenario may even be conservative because higher rates of growth in energy consumption were experienced during the growth decade of the 1960s. Since the early 1970s, the energy crises, foreign indebtedness and political instability, including wars, have stunted economic growth in many developing countries. With such obstacles removed, the experience of the newly industrialized countries of South-East Asia may be more to the point.

26. Future energy consumption trends will depend on overall economic growth, changes in the structure of national economies and technological developments in energy production and use.

27. As noted in a recent report of the Secretary-General entitled "Structural change in the world economy: implications for energy use and air emissions" (A/47/388), world energy intensities were expected to improve considerably. Nevertheless, by the year 2020, the developing countries would only achieve the energy intensity level of the developed market economies in 1973 (see table 3).

Table 3. Energy intensity a/

	1960	1973	1988	2000	2020
World	0.82	0.78	0.67	0.61	0.48
Developed market economies	0.70	0.7	0.5	0.42	0.29
Economies in transition	2.01	1.79	1.48	1.3	0.54
China and former centrally planned economies in Asia	2.59	1.92	1.39	1.24	1.03
Newly industrializing economies	0.44	0.52	0.54	0.55	0.49
Other developing countries	0.28	0.34	0.62	0.78	0.61

Source: UN/DPCSD, based on the report of the Secretary-General entitled "Structural change in the world economy: implications for energy use and air emissions" (A/47/388).

a/ Measured in metric tons of coal equivalent per thousand United States dollars of GDP, in 1980 United States dollars and at 1980 exchange rates, historical and projected under the high-growth scenario, by region.

28. Despite lower growth rates in gross domestic product (GDP) expected by the year 2020, even under the most optimistic assumptions, as shown in table 4, and improvements in energy efficiencies, world-wide consumption of fossil fuels will increase to 13,754 mtoe from 6,894 mtoe in 1990. About 70 per cent of this increase will be in the developing countries. Nevertheless, under this optimistic scenario of steady economic growth during the next three decades, disparities between the industrialized world and the developing countries will still be significant. In this high growth scenario, the developed market economies will increase their GDP from $16.6 trillion in 1990 to $38.5 trillion in the year 2020, while their per capita GDP will jump from $18,295 to $36,771. Comparable estimates for the developing world show an increase in total GDP from $3.9 trillion to $14.5 trillion and per capita GDP from $974 to $3,655.

29. Fossil fuel consumption in the developed market economies will increase by 37.8 per cent, from 3,440 to 4,742 billion tons of oil equivalent (bto) and on a per capita basis by 19.5 per cent, from 3,786 to 4,525 koe. In the developing world, total fossil fuel consumption will jump by 268.2 per cent, from 1,782 to 6,563 btoe, and by 267.8 per cent per capita, from 450 to 1,655 koe.

Table 4. GDP and fossil fuel consumption, 1990 and 2020

	1990				2020				Growth rate in fossil fuel consumption 1990-2020 (percentage)
	GDP		Fossil fuel consumption		GDP		Fossil fuel consumption		
	Total	Per capita	Total	Per capita	Total	Per capita	Total	Per capita	
World	22 325.6	4 230.2	6 893.5	1 306.1	56 812.9	7 046.4	13 754.1	1 705.9	2.23
Developed market economies	16 626.8	18 295.4	3 440.6	3 786.0	38 536.1	36 771.1	4 742.2	4 524.9	1.04
Economies in transition	1 835.8	4 538.4	1 670.6	4 129.9	3 786.7	8 051.7	2 449.2	5 207.8	1.23
Developing countries	3 862.9	974.4	1 782.3	449.5	14 490.2	2 214.1	6 562.7	1 002.8	4.21
Newly industrial-izing countries	1 550.8	2 526.1	430.9	702.0	6 244.3	6 832.5	1 484.1	1 623.9	4.00
Other developing countries	1 958.7	894.5	663.0	302.8	6 566.8	1 590.7	2 475.7	599.7	4.26
Centrally planned Asia	353.4	304.5	688.4	593.0	1 679.1	1 117.7	2 602.9	1 732.6	4.30

Source: UN/DPCSD, based on the Global Input-Output Model (GIOM) of UN/DESIPA.

Notes: GDP: billions of constant 1990 United States dollars.

GDP per capita: constant 1990 United States dollars.

Energy: million tons of oil equivalent.

Energy per capita: kilograms of oil equivalent.

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30. Such a rapid growth in energy demand, especially of fossil fuels, gives rise to environmental concerns at the national, regional and global levels. As shown in table 5, the projected increases in annual consumption of fossil fuels under the high-growth scenario would result in large increases of air emissions of carbon and nitrogen compounds but much smaller increases of sulphur emissions and even decreases in several regions. Large reductions per unit of GDP would be achieved in the developed market economies. For the economies in transition, somewhat smaller improvements are projected, except for sulphur emissions. Much smaller changes, compared with historical trends, are projected for the developing countries (see A/47/388, table 5).

Table 5. Air emissions, 1990 and 2020

	1990			2020		
	Carbon a/	Sulphur oxides b/	Nitrogen c/	Carbon a/	Sulphur oxides b/	Nitrogen c/
Developed market economies	2 790	45	35	3 800	45	43
Economies in transition and CIS	1 320	45	21	1 900	37	29
Developing countries	1 530	37	22	5 550	99	83
World	5 640	127	78	11 250	181	154

Source: Report of the Secretary-General entitled "Structural change in the world economy: implications for energy use and air emissions" (A/47/388), table 6.

a/ Carbon from fossil fuels (millions of metric tons).

b/ Sulphur oxides (millions of metric tons of sulphur dioxide equivalent).

c/ Millions of metric tons of nitrogen dioxide equivalent.

II. ENERGY RESERVES AND PRODUCTION PATTERNS

A. Oil and natural gas

31. Because of the widespread and increasing use of commercial energy in all economic sectors of modern societies, various concerns have often been expressed about the adequacy of reserves and resources to meet future demand. Such concerns are based on experiences of energy shortages caused by wars, embargoes, political instabilities and the exhaustion of what were once prolific deposits, as well as by the perception that reserves and resources are finite. Yet, paradoxically, the more energy the world consumes, the more energy reserves, more often than not, are found. This has been the case in the past 20 to 25 years with regard to all energy reserves, but more so with respect to oil, which has given rise to most concerns.

32. The main reason for this fortunate state of affairs is the veritable explosion in new petroleum technologies which have opened up vast frontier areas of petroleum potential in deserts, jungles, the Arctic and, most importantly, offshore.

33. Before 1970 there was hardly any oil production offshore. Today about one third of world oil production comes from offshore fields which are progressively being developed at deeper depths. The Campos basin, offshore Rio de Janeiro, and the Gulf of Mexico, in the United States, are now producing at a depth of more than 2,000 feet, and future production is contemplated at double that depth. By comparison, North Sea fields are 600 to 700 feet deep.

34. Oil exploration techniques such as geochemical modelling, satellite imagery, seismic surveys and associated computer technologies have not only expanded the horizons of exploration specialists, they have also deepened their understanding, especially through three-dimensional (3-D) seismic technology, of complex geological formations which have reduced risks in drilling and consequently resulted in reduced exploration costs. A study by the University of Texas claimed that 3-D seismic technology could eventually add 620 billion barrels of proved reserves world wide. 3/ Similarly, additional reserves could be achieved with drilling technologies that now reach deeper depths and are able to produce a higher proportion of the oil in place, especially with the wider application of horizontal drilling and modern secondary and tertiary recovery methods and technologies.

35. In this respect it has been reported that the pay-off from horizontal drilling in the United States could be at least several billion barrels of oil added to production in the next 15 to 20 years. Indeed, drillers in south Texas have made large profits, even with oil prices below $17 a barrel, because horizontal drilling has slashed drilling costs from $12 to $4 a barrel. Averaging about $1 million, a horizontal well is twice as costly as a vertical well, but some production rates have been four or five times as great and drilling costs are often recovered within a year. 4/

36. Similarly, because of the improving ability to identify and extract oil, the amount of recoverable reserves has barely slipped in the United States during the 1980s. The number has remained fairly steady even though the United States is pumping about 3 billion barrels of oil a year and even though the amount discovered annually in previously unexplored areas has dropped 30 per cent from peaks in the early 1980s to well below 1 billion barrels a year. With gains in technology, some experts say the recovery rate for proved reserves can rise to one of every two discovered barrels - enough to more than double the supplies once expected to run out within 60 years or so. The industry has recovered an average of one of every three barrels from domestic reserves in recent years. 5/

37. Much of what has been said above applies also to natural gas, which is often produced in association with oil.

38. In addition to great advances in oil and gas exploration and production technologies, equally important developments in continental and undersea pipelines as well as supertankers and liquefied natural gas LNG or methane tankers have narrowed distances between far-away resources and markets, which also contributed to the increase in reserves.

39. Many of the advances in petroleum technologies were developed by independent contractors and widely applied by the transnational oil corporations of the industrialized world either in their home countries or in foreign countries through long-term petroleum exploration and development agreements involving foreign direct investments. Until recently, however, the economies of Eastern Europe and the former Soviet Union, as well as many developing countries, did not welcome foreign direct investments in petroleum for a variety of ideological, political and economic reasons.

40. The political transformation of the past few years, especially of the former Soviet Union, and the widespread adoption of free market policies in most of the developing countries have opened up vast new areas with considerable oil and gas potential. In fact, in Azerbaijan and Kazakhstan, agreements already reached with Western European and United States oil companies call for the application of modern offshore technologies and production technologies for complex reservoirs respectively for oil already discovered. Similarly, China has recently invited bids from foreign oil companies for exploration onshore for the first time.

41. For years, before the wave of nationalization in several of the member countries of OPEC during the late 1960s and early 1970s, hardly any exploration by the transnational oil corporations took place in those countries because of low oil prices, insecurity as to the durability of their concessions and vast reserves already discovered. In countries such as the Islamic Republic of Iran, Iraq, Kuwait, Saudi Arabia and Venezuela reserves and production capacities had been established at high levels. Consequently, the drop in demand for OPEC oil during the 1980s left much of this capacity unused until the resumption of demand in the past few years. In the other member countries of OPEC (e.g., Algeria, Ecuador, Gabon, Libyan Arab Jamahiriya, Indonesia, Nigeria, Qatar and the United Arab Emirates), exploration continued through a combination of

efforts by the national oil companies of those countries and transnational oil corporations.

42. As a result of this effort and significant revisions of published estimates, the magnitude of reserves in OPEC member countries increased by 76.6 per cent between 1979 and 1991, as shown in table 6.

43. Recently, a few of the member countries of OPEC that had nationalized foreign concessions have taken initiatives to attract foreign participation with capital and modern technologies in the upstream of their petroleum sector, including exploration, improvement of recovery factors in producing fields and new areas such as liquefied natural gas and heavy oil development.

44. Algeria, for example, has adopted a new hydrocarbon strategy aiming at (a) increasing the size of the resource base, both in oil and gas, through a boost in exploration efforts and expenditures; (b) improving the rate of recovery of existing reserves through additional development and enhanced recovery projects; (c) developing all the known gas fields, which have, so far, been neglected, including those located in the deep south; (d) sustaining the overall level of oil and gas exports at the equivalent of some 1.8 million barrels a day in the short and medium term and, it is hoped, achieve a 50 per cent increase in those exports by the turn of the century.

45. In order to attract the participation of transnational oil corporations, changes in national legislation include (a) a more competitive fiscal package based on a production-sharing type agreement; (b) the possibility of participating in discovered or producing fields, including potential access to current production; and (c) the right to share in natural gas discoveries, which was previously reserved exclusively for Sonatrach, the national petroleum company of Algeria. 6/

46. Similarly, Venezuela has embarked on a reactivation programme for marginal oilfields with the participation of foreign oil companies, the development of heavy crude for increased exports of Orimulsion, a liquid emulsion of extra-heavy oil or natural tar with 30 per cent water, already used in electric power generation, with foreign oil and electricity companies, the upgrading of heavy oil to light oil and a $5.6 billion LNG project with Shell, Exxon and Mitsubishi. 7/

Table 6. World proved oil reserves, end 1979 and end 1991

	End 1979		End 1991	
	Millions of barrels	Percentage of world	Millions of barrels	Percentage of world
Developed market economies	58 796	9.2	47 555	4.8
Eastern Europe and CIS	70 000	10.9	58 774	5.9
Developing countries	512 545	79.9	884 682	89.3
OPEC member countries	435 611	67.9	769 392	77.6
Other oil-exporting countries	69 930	10.9	101 826	10.3
Oil-importing countries	7 004	1.1	13 464	1.4
World total	641 341	100.0	991 011	100.0

Source: UN/DPCSD, based on Oil and Gas Journal, 24 December 1979 and 30 December 1991.

47. In the rest of the developing countries much of the petroleum exploration effort has been concentrated in 19 non-OPEC oil-exporting countries (including Angola, Brunei Darussalam, Cameroon, China, Colombia, Egypt, Malaysia, Mexico, Oman, Papua New Guinea, Syrian Arab Republic, Trinidad and Tobago, Tunisia and Yemen) and 19 oil-importing countries (including Brazil, India, Pakistan, Thailand and Turkey) (see table 7). In more than 60 developing countries and territories with no oil production at all, little exploration effort has been made.

48. Petroleum exploration and production developments during the past 20 years or so have resulted in a wider geographic diversification of supplies. Despite many fluctuations during this period, incremental oil production was mainly due to the non-OPEC oil-exporting developing countries, the developed market economies, the countries of the former Soviet Union and the oil-importing developing countries.

49. What about the future? How long will petroleum supplies last and which countries are likely to be the main suppliers?

Table 7. Oil wells drilled and incremental oil reserves in developing countries

	Number of wells (1982-1990)		Oil reserves (Million barrels)		
	Exploratory	Development	1979	1990	Increment
OPEC countries	3 254	12 393	435 611	769 392	333 781
Non-OPEC oil-exporting developing countries	3 376	9 789	69 930	101 826	31 896
Oil-producing/ importing developing countries	6 100	18 608	7 004	13 464	6 460
Non-oil-producing developing countries	267	43	..	..	..

Source: UN/DPCSD, based on the report of the Secretary-General on energy exploration and development trends in developing countries (A/47/202-E/1992/51).

Note: Data on exploratory and development wells drilled in China were available only from 1987 onwards and were not included in the table to avoid an anomalous increase in the number of wells completed in relation to years prior to 1987. The number of wells drilled in China in 1987, 1988, 1989 and 1990 were as follows: exploratory wells, 1,525, 1,642, 1,665 and 1,697, respectively, and development wells, 5,706, 5,809, 5,860 and 5,930, respectively.

50. The most widely held view among petroleum experts is that the geology of all of the world's sedimentary basins with petroleum potential is at least partially known. However, estimates on a global basis vary from 2,000 billion to 6,000 billion barrels of recoverable conventional oil based on different expectations of both technological developments and economic conditions, especially with regard to costs and price. In the past, all these parameters moved in different directions than generally expected. Prognostications about their future behaviour should therefore be interpreted with great caution. In any case, the estimates of one authority on this subject are presented in table 8.

51. World cumulative oil production is estimated at 640.7 billion barrels. Remaining oil is 1,650.5 billion barrels, consisting of 976.5 billion barrels of proved reserves and 674 billion barrels of probable reserves additions. At the rate of world oil production in 1991 of 21.9 billion barrels, the world's remaining oil is adequate for 75 years.

52. Besides conventional oil, vast oil potential is known, for example, in the Orinoco tar belt of Venezuela, the Athabasca tar sands of Canada and the mountains of oil shales in Colorado in the United States. Commercial production is already in progress with heavy oil in Venezuela and tar sands in Canada. However, large expansions of production from unconventional oil sources are not expected in the foreseeable future because of much higher costs.

Table 8. World oil distribution

(Billion barrels)

Country	Cumulative production	1991 production	Proved reserves	Reserves/ production ratio	Probable a/ reserves addition	Remaining oil	Total oil
Saudi Arabia b/	62.4	3.03	257.8	86/1	42	299.8	362.20
Commonwealth of Independent States	112.2	3.74	57.0	15/1	124	181.0	293.20
United States of America	158.0	2.69	26.3	10/1	71	97.3	255.30
Iran, Islamic Republic of b/	39.1	1.22	92.9	76/1	52	144.9	184.00
Iraq b/	22.4	1.03 c/	100.0	100/1	45	145.0	167.40
Venezuela b/	44.7	0.85	59.0	69/1	38	97.0	141.70
Kuwait b/	26.5	0.64 c/	94.0	147/1	4	98.0	124.50
United Arab Emirates b/	12.6	0.88	98.1	111/1	49	147.1	159.70
Mexico	17.5	1.01	52.0	51/1	52	104.0	121.50
China	15.7	1.02	24.0	24/1	48	72.0	87.70
Canada	14.3	0.56	5.6	10/1	33	38.6	52.90
Libyan Arab Jamahiriya b/	17.4	0.55	22.8	41/1	8	30.8	48.20
Nigeria b/	13.4	0.68	17.9	26/1	9	26.9	40.30
Indonesia b/	13.7	0.52	6.6	13/1	10	16.6	30.30
Norway	4.0	0.68	7.6	11/1	22	29.6	33.60
United Kingdom of Great Britain and Northern Ireland	10.3	0.65	4.0	6/1	13	17.0	27.30
Algeria b/	8.3	0.29	9.2	32/1	2	11.2	19.50
Egypt	5.2	0.32	4.5	14/1	5	9.5	14.70
India	3.0	0.24	6.1	25/1	3	9.1	12.10
Brazil	2.9	0.23	2.8	12/1	8	10.8	13.70
Australia	3.3	0.20	1.5	8/1	5	6.5	9.80
Oman	3.3	0.26	4.3	17/1	2	6.3	9.60
Argentina	5.3	0.17	1.1	19/1	2	3.1	8.40
Malaysia	2.2	0.23	3.1	13/1	4	7.1	9.30
Qatar b/	4.4	0.14	3.7	26/1	2	5.7	10.10
Colombia	3.1	0.16	2.0	12/1	2	4.0	7.10

Country	Cumulative production	1991 production	Proved reserves	Reserves/ production ratio	Probable a/ reserves addition	Remaining oil	Total oil
Tunisia	0.8	0.04	1.7	43/1	4	5.7	6.50
Romania	4.7	0.05	1.2	24/1	1	2.2	6.90
Yemen	0.2	0.07	4.0	57/1	2	6.0	6.20
Ecuador b/	1.7	0.11	1.6	14/1	3	4.6	6.30
Angola	1.7	0.18	1.8	10/1	2	3.8	5.50
Brunei Darussalam	2.0	0.05	1.4	28/1	2	3.4	5.40
Peru	1.8	0.04	0.4	10/1	3	3.4	5.20
Trinidad and Tobago	2.6	0.05	0.5	10/1	2	2.5	5.10

Source: UN/DPCSD, based on the report of the Secretary-General on energy exploration and development trends in developing countries (A/47/202-E/1992/51).

Note: Some countries, e.g., Gabon and Cameroon, are not mentioned in the table owing to lack of information on probable reserves addition.

a/ Probable reserves addition comprises estimated field growth and undiscovered recoverable resources.

b/ OPEC member country.

c/ Annual oil productions of Iraq and Kuwait are for 1989, prior to the Gulf war, for more realistic levels.

53. Most of the world's oil is concentrated in the developing countries, which account for about 70 per cent of total oil (cumulative production plus remaining oil), 52 per cent of cumulative production, 89 per cent of proved reserves and 77 per cent of all remaining oil. Within the developing world, much of the concentration is in the OPEC member countries, especially in the Middle East.

54. The developed market economies account for only 16.5 per cent of total oil, 29.6 per cent of cumulative production, only 4.6 per cent of proved reserves and 11.5 per cent of all remaining oil.

55. It may also be interesting to note that, between 1987 and 1990, significant declines in proved reserves have been registered in practically all the industrialized countries: 20.9 per cent in Australia and New Zealand, 22.3 per cent in Norway and the United Kingdom and 7.1 per cent in Canada and the United States. 8/

56. This concentration is significant because of the sheer size of the oil resources involved as well as because of the low operating cost of their production and low capital investment requirements for new production capacities. A recent study on Saudi Arabia, for example, has estimated operating costs at $1.70 per barrel and investment requirements at $1.30. 9/

57. Comparable costs in the developed market economies would be at least three to five times as much.

58. Yet, as in the past, future oil production patterns are unlikely to be determined by free market considerations alone, which would dictate much more production in the developing world relative to the industrialized countries and much more oil import dependence by the latter countries.

59. Reserves to production ratios have been much lower in the industrialized countries. The magnitude of their own probable reserves as well as similar reserves in the countries of the former Soviet Union and a number of non-OPEC developing countries are likely to provide opportunities for wider geographic diversification of supplies as a matter of national policies rather than global economic efficiency. Much will depend on national policies, including restrictions on access to proved and probable reserves for environmental reasons, political as well as technological developments and the price of oil, which, at present, has little to do with costs of production. Higher oil import dependence by some industrialized countries and a number of energy-deficient developing countries may thus be postponed for even higher imports in the longer term.

60. World proved reserves of natural gas have also increased considerably during the past two decades. Much of the increase is in the former Soviet Union and the developing world. However, a decline was registered in the developed market economies (see table 9).

Table 9. Natural gas reserves

(Trillion cubic metres)

	Proved recoverable reserves		Estimated additional reserves recoverable	
	1970	1990	At end 1990	Percentage
Developed market economies	13.25	13.08	17.8	15.4
Eastern Europe and CIS	9.89	55.07	35.8	30.9
Developing countries	18.68	60.7	62.13	53.7
WORLD	41.82	128.85	115.73	100.0

Source: UN/DPCSD, based on the report of the Secretary-General on energy exploration and development trends in developing countries (A/47/202-E/1992/51) and World Energy Council, 1992 Survey of Energy Resources, sixteenth edition, tables 4.1 and 4.4.

61. With an annual production of 2,470 billion cubic metres, proved reserves at 129 trillion cubic metres are adequate for 52 years, or somewhat longer than for conventional oil. The adequacy of natural gas is extended to over 100 years by accounting for another 116 trillion cubic metres of additional recoverable reserves. In fact, the ultimate resource base of conventional gas has been put as high as 500 trillion cubic metres. 10/

62. As with oil, unconventional gas resources are also extensive.

63. As a group, the developing countries are well endowed with natural gas, with about 47 per cent of proved and 55 per cent of additional recoverable reserves of the world total. However, within the developing world, three quarters of the proved and additional recoverable reserves together are concentrated in the member countries of OPEC.

64. The former Soviet Union has by far the largest proved and additional recoverable reserves on a country basis, followed by the Islamic Republic of Iran, the United States, Saudi Arabia and Qatar.

65. Although the share of the developed market economies as a group in world proved and additional recoverable reserves at 30.9 trillion cubic metres is only 9 per cent, the magnitude of the gas reserves is 200.9 billion barrels of oil equivalent as compared to 189 billion barrels of comparable reserves of conventional oil.

66. At present, exports of natural gas are mainly from the former Soviet Union to Eastern and Western European countries, from the Netherlands and Norway to Western Europe, from Algeria to Western Europe and from Indonesia and Brunei Darussalam to Japan, the Republic of Korea and Taiwan Province of China. Future

export plans involve both additional LNG projects and a variety of continental and intercontinental pipelines, including extensive undersea pipelines.

67. Practically all projections indicate consistent increases in natural gas consumption in all the regions of the world in the foreseeable future. Most expect the annual rate of growth to be considerably higher for gas than for oil because of its less deleterious environmental effects, especially with regard to emissions of carbon dioxide. However, natural gas has limited substitution possibilities given the oil dominance in the transportation sectors. Moreover, capital investment requirements are much higher, especially in developing countries that lack extensive natural gas distribution systems. Nevertheless, natural gas demand in non-energy sectors such as petrochemicals and fertilizers may give an additional boost even in coal-dominated developing economies such as China and India which may resort to imports because of lack of indigenous gas resources.

B. Coal

68. Since the energy crisis of the early 1970s, coal consumption has increased by 58.6 per cent as compared to 54.3 per cent for oil and 100 per cent for natural gas, mainly because of a massive expansion in China and considerable increases in India and the developed market economies.

69. Coal became more competitive because of higher oil prices but it also benefited from a variety of favourable measures such as subsidies in Germany, Japan and the United Kingdom and restrictions in the use of oil for electric power generation by member countries of the International Energy Agency.

70. As shown in table 10, coal reserves (bituminous, sub-bituminous and lignite) are adequate for about 200 years, much longer than either oil or natural gas.

71. Despite the magnitude of coal reserves, their geographic distribution is less diverse than for oil and gas. Six countries - the United States of America, the former Soviet Union, China, 11/ India, South Africa and Australia - account for 85 per cent of world bituminous coal reserves.

72. Apart from the major coal reserves of China and India, and smaller reserves in a few other countries (e.g., Colombia, Indonesia, Turkey, Venezuela and Viet Nam), the developing world is not well endowed. Imports of coal for power generation in those countries have been limited mainly because of the lack of appropriate infrastructure and the need for heavy front-end investments.

73. International trade in coal remains limited to about 10 per cent of world consumption, although it is increasing because of the exhaustion of economic reserves in Western Europe and the consequent increases in imports, as well as because of additional demand, especially in the fast-growing economies of Asia. Despite progress with clean coal technologies, harmful dust, sulphur-dioxide and nitrogen-oxide emissions are still a problem in several countries and emissions of carbon dioxide are widely considered to be harmful to the global environment.

Table 10. Coal: proved recoverable reserves and production, 1990

(Millions of tons)

	Bituminous	Sub-bituminous	Lignite	Total
Reserves				
Developed market economies	192 544	101 653	136 665	430 862
Eastern Europe and CIS	136 167	40 292	138 990	315 449
Developing countries	186 702	47 540	52 629	286 871
WORLD	515 413	189 485	328 284	1 033 182
Production				
World production in 1990	3 810	305	1 130	4 745
Reserves/production ratio (R/P) (years)	155.7	621.3	290.5	217.6

Source: UN/DPCSD, based on World Energy Council, 1992 Survey of Energy Resources, sixteenth edition, tables 1.1 and 1.2.

C. Electric power

74. Electricity consumption has been growing faster than other energy products. This reflects the great versatility in uses in practically all economic sectors, except transportation where experimentation with electric cars is still in its infancy.

75. As indicated in table 11, world electricity production remains heavily dependent on fossil fuels despite a more than threefold increase during the 1980s in nuclear power generation, mainly in the developed market economies, and considerable increases in hydropower, especially in the developing countries.

76. Much of the increase in electricity production in the developed market economies has been based on nuclear power. Electricity generation based on heavy fuel oil has been drastically reduced, while the use of coal and natural gas is increasing. The future of nuclear power is widely questioned on economic and safety grounds and because of unsolved problems connected with the decommissioning of old plants and the disposal of radioactive wastes.

77. Similar and even more serious problems exist in nuclear power plants in Eastern Europe and the former Soviet Union.

78. In the developing world, fossil fuels dominate the electricity sector, followed by hydropower and, in a few countries, the introduction of nuclear power. With electricity production expected to increase at more than double the rate in the rest of the world, new policies and measures may be required for the intensified utilization of the vast hydropower potential of the developing countries, which is now hampered by a variety of factors, including new environmental concerns.

Table 11. Production of electricity by type

(Million kilowatt hours)

	Year	Thermal	Hydro	Nuclear	Geothermal	Total
Developed market economies	1980	3 584 575	1 058 599	581 798	10 097	5 235 069
	1991	4 372 450	1 177 112	1 701 186	26 491	7 277 239
Annual growth rate (percentage)		1.81	0.97	9.79	8.80	3.00
Eastern Europe and CIS	1980	1 438 188	236 581	82 577	0	1 757 346
	1991	1 591 112	280 098	267 180	30	2 138 420
Annual growth rate (percentage)		0.92	1.54	10.72	N/A	1.79
Developing countries	1980	774 899	459 830	16 830	3 357	1 254 916
	1991	1 717 806	778 545	109 639	12 431	2 618 421
Annual growth rate (percentage)		7.26	4.80	17.16	11.96	6.71
Total world	1980	5 797 662	1 755 010	681 205	13 454	8 247 331
	1991	7 681 368	2 235 755	2 078 005	38 952	12 034 080
Annual growth rate (percentage)		2.56	2.20	10.18	9.70	3.44

Source: UN/DPCSD, based on Energy Statistics Yearbook, various issues.

III. FINANCIAL REQUIREMENTS AND INVESTMENTS

79. The expected growth in energy production and consumption in the developing countries will require considerable investments. By far the largest investments will be required in the electricity sector. During the current decade, developing countries will require a near doubling of installed capacity, from about 590 gigawatts in 1990, with a total investment of over $1 trillion (1989 dollars). 12/ In the energy-deficient developing countries, electricity capacity expansions during the 1990s will require cumulative capital investments of $449 billion, of which $150 billion will be in foreign exchange. 13/ Similarly, the Secretary-General of OPEC has indicated, in various statements made at several forums, that some $120 billion will be needed by the year 2000 in the member countries of OPEC for maintaining and expanding oil production capacities.

80. Investments in oil exploration and development by transnational oil corporations in oil-importing developing countries have dropped considerably since the oil price collapse of 1986. 14/ Yet, it is estimated that, without any improvement in their import dependence, these countries will need at least $20 billion during the next 10 years for the development of indigenous oil. During the same period, their annual oil import bills may climb from $36 billion at present to $58 billion.

81. Energy projects are both capital-intensive and long-term. The exploration and production of coal, oil or gas usually require 5 to 15 years. Similarly with electric power plants. Billions of dollars are often required for a single energy project.

82. The need for capital for new energy projects is quite obvious. What is often overlooked is the need for vast amounts of capital to maintain the production capacity of energy projects.

83. In this respect, various studies have demonstrated serious losses from the lack of adequate investments in the electricity sector. Up to 30 per cent of electricity production is lost in the developing countries because of inadequate maintenance of generation and transmission facilities. This is further compounded by inefficient, electricity-guzzling equipment in the household, agricultural, industrial and service sectors. Similar losses are becoming more obvious in oil and gas, especially oil, as demonstrated by recent developments in the former Soviet Union.

84. In the electricity sector, post-Second World War financing practices, with the significant exception of the United States and a few other countries, have been dominated by the public sector because of the utility function of electricity projects and prevalent economic development theories. These practices were influenced by the urgent need to reconstruct facilities and new methods of financing through, for example, the Marshall Plan and the World Bank. World Bank lending for electricity projects in the developing world has been significant. About one third of the Bank's loans have been in this sector. Furthermore, World Bank involvement has been essential in attracting additional financing from bilateral sources through the export guarantee mechanism of

export-import banks and similar facilities in the industrialized world and the international capital markets.

85. Because of the magnitude of profitabilities and the strategic importance of oil, financing of this sector has been politically sensitive. Major transnational oil corporations, mainly those from the United States, the United Kingdom, France and the Netherlands, were dominant until the nationalization of oil concessions in the 1970s. Since then, transnational oil corporations from Western Europe and Japan and the national oil companies of developing countries have increased their participation significantly. With brief and rather insignificant exceptions, oil financing from the World Bank and bilateral public sources has been limited.

86. The privatization movement of the 1980s has recently gained strength with regard to energy projects in the developing world. For example, the Government of Argentina has sold more than $3 billion worth of shares, or 45 per cent of its state oil company, Yacimientos Petroliferos Fiscales (YFP) in the largest privatization on record in Latin America. 15/

87. In the electricity sector, a few public utility companies have been either wholly or partly privatized. New electricity plants in some countries are being financed through B.O.T. (build-operate-transfer) schemes which involve international consortia of transnational corporations as suppliers of energy (e.g., coal companies) and equipment (e.g., electric power plant manufacturers), with guarantees from their national export-import banks in the industrialized world and local government or private financing (e.g., Pakistan and Turkey). Similar projects are being reported for electricity generation based on hydropower, natural gas and heavy oil.

88. Because of the slow growth, deregulation and privatization of electricity utilities in various developed market economies, the high rate of growth in electricity demand in the developing countries and, consequently, heavy investment requirements, projects for foreign direct investment have been initiated and others are being contemplated. 16/ For such development to intensify, in many developing countries parallel deregulation and the opening up of their electricity markets will be necessary. Subsidies estimated by the World Bank at $100 billion per year for electricity consumption in the developing countries are inconsistent with enhancing the role of foreign direct investment in this sector. 17/

89. As indicated in section II of the present report, countries that were at the forefront of nationalization during the 1960s and 1970s are reversing their course and policies aimed at the involvement of transnational oil corporations. Algeria is awarding contracts not only for new exploration but also for existing and producing fields in order to provide financing for the repayment of foreign debt and to improve production capacities through the application of modern methods and technologies. Venezuela is involving transnational oil corporations in its plans for heavy oil development, the development and export of offshore liquefied natural gas and the application of modern technologies in marginal oil fields. The Islamic Republic of Iran has signed protocols for offshore oil developments, and China has invited oil company participation on land as well. Changes in the former Soviet Union have already resulted in many new financing

mechanisms in energy which involve transnational corporations as well as existing multilateral agencies (e.g., the World Bank) and new institutions and instruments (e.g., the European Bank for Reconstruction and Development and the European Energy Charter).

IV. CONCLUSIONS

90. Energy is an essential input for economic and social development. The exploration and development of low-cost energy resources has fuelled the advance of the industrialized world and many developing countries.

91. The rapid application of new technologies has enhanced conventional energy supplies and kept down their real costs. With rising incomes, the impact of energy costs has been reduced.

92. The industrialized world has reached high levels of energy consumption. Energy conservation and efficiency measures have reduced energy intensities and further improvements are expected. Although much remains to be done, increasing investments in energy producing and consuming sectors for environmental abatement have had positive results. Increasing energy imports, especially oil, because of growing demand and exhaustion of once prolific domestic reserves, gives rise to concern about the security of supplies. Deregulation of energy enterprises has increased competition and foreign operations are being augmented. Future economic growth will require additional inputs of fossil fuels, with consequent concern about environmental effects, especially on climate change.

93. In the economies in transition, political transformations and openness have revealed massive mismanagement of energy resources, which caused the rapid exhaustion of reserves and deleterious environmental problems. Reorganization of the energy-producing and consuming sectors has proved to be much more complex than originally thought. The adjustment process and the future are uncertain.

94. In the developing world, the energy-exporting countries have the physical energy resources for augmented supplies to the industrialized countries and the energy-importing developing countries. Their economic transformation during the period of high energy prices has stalled. Reduced energy export earnings at a period of high population growth and high costs of maintenance of new infrastructures have led to uncertainties about their abilities to finance new energy export capacities. These uncertainties are compounded by existing energy import restrictions and new energy and environmental taxes in consuming countries, with consequent concern about the security of energy demand.

95. The foreign exchange outlays of the energy-importing developing countries remain high and are expected to become even more onerous in the future. The lack of capital and modern technologies hinder exploration and development of indigenous potential energy resources. Additional incentives and more free market reforms have not attracted adequate foreign direct investment.

96. In many developing countries, even energy-exporting ones, shortages of fossil fuels and/or electricity often cause severe losses of economic output. The number of the energy poor is growing, particularly in rural areas. Yet economic growth and the consequential increase in energy consumption are imperatives for meeting the needs of a growing population and tackling serious local as well as global environmental problems. While national efforts to alleviate these problems are essential, their solution would require expanded international cooperation and special measures.

Notes

1/ World Economic Survey, 1993 (United Nations publication, Sales No. E.93.II.C.1), annex, table A.39.

2/ See General Assembly resolution 45/209 of 21 December 1990.

3/ "New techniques - renew oil search in old familiar places", Petroleum Intelligence Weekly, 24 April 1989.

4/ "Horizontal drilling or how to revive oilfields", The New York Times, 4 July 1990, p. 46.

5/ "New tools aid oil hunt in U.S.", The New York Times, 16 May 1989.

6/ Nordine Ait-Laoussine, "The new upstream environment: opportunities and constraints - the Algeria case", Middle East Economic Survey, 19 April 1993.

7/ PDVSA Contact Newsletter, No. 33, May-June 1993.

8/ World Energy Council, 1992 Survey of Energy Resources (ISBN: 0 946121 07 9), p. 39.

9/ Middle East Economic Survey, 15 October 1993, p. A5.

10/ 1992 Survey of Energy Resources, p. 67.

11/ China has reassessed its coal reserves (bituminous, sub-bituminous and lignite) at 114 billion tons, as compared to 731 billion tons in 1987 (see 1992 Survey of Energy Resources, p. 17).

12/ See "Report on the Stockholm Initiative on Energy, Environment and Sustainable Development (SEED): Strategies for implementing Power Sector Efficiency, Stockholm, 13-15 November 1991", key issue papers.

13/ "Capital expenditures for electric power in developing countries in the 1990s", Energy and Industry Working Paper, Energy Series Paper No. 21 (Washington, D.C., World Bank, February 1990).

14/ "Capital expenditures by majority-owned foreign affiliates of U.S. companies", Survey of Current Business (Washington, D.C., United States Department of Commerce), various issues.

15/ The New York Times, 29 June 1993, p. D2.

16/ "U.S. electronic companies see promised land elsewhere", The Wall Street Journal, 3 March 1993, p. B4.

17/ "Energy efficiency and conservation in the developing world", World Bank Policy Paper (Washington, D.C., World Bank, 1993), p. 14.